PATENT COOPERATION TREATY

From the
INTERNATIONAL SEARCHING AUTHORITY

To:
HULSE, ROBERT A.

FENWICK & WEST LLP SILICON VALLEY CENTER 801
CALIFORNIA STREET MOUNTAIN VIEW CA 94041 USA

PCT

WRITTEN OPINION OF THE INTERNATIONAL SEARCHING AUTHORITY

(PCT Rule 43bis.1)

Date of mailing *(day/month/year)* **15 September 2017 (15.09.2017)**

Applicant's or agent's file reference
31718-33990/PCT

FOR FURTHER ACTION
See paragraph 2 below

International application No.	International filing date *(day/month/year)*	Priority date *(day/month/year)*
PCT/US2016/069633	**31 December 2016 (31.12.2016)**	27 December 2016 (27.12.2016)

International Patent Classification (IPC) or both national classification and IPC
H01L 41/09(2006.01)i, H01L 41/193(2006.01)i, H01L 41/25(2013.01)i, H01L 41/27(2013.01)i, G06F 3/01(2006.01)i

Applicant
OCULUS VR, LLC

1. This opinion contains indications relating to the following items:

- [x] Box No. I Basis of the opinion
- [ ] Box No. II Priority
- [ ] Box No. III Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
- [ ] Box No. IV Lack of unity of invention
- [x] Box No. V Reasoned statement under Rule 43bis.1(a)(i) with regard to novelty, inventive step and industrial applicability; citations and explanations supporting such statement
- [ ] Box No. VI Certain documents cited
- [x] Box No. VII Certain defects in the international application
- [ ] Box No. VIII Certain observations on the international application

2. **FURTHER ACTION**

If a demand for international preliminary examination is made, this opinion will be considered to be a written opinion of the International Preliminary Examining Authority ("IPEA") except that this does not apply where the applicant chooses an Authority other than this one to be the IPEA and the chosen IPEA has notified the International Bureau under Rule 66.1bis(b) that written opinions of this International Searching Authority will not be so considered.

If this opinion is, as provided above, considered to be a written opinion of the IPEA, the applicant is invited to submit to the IPEA a written reply together, where appropriate, with amendments, before the expiration of 3 months from the date of mailing of Form PCT/ISA/220 or before the expiration of 22 months from the priority date, whichever expires later.
For further options, see Form PCT/ISA/220.

Name and mailing address of the ISA/KR	Date of completion of this opinion	Authorized officer
International Application Division Korean Intellectual Property Office 189 Cheongsa-ro, Seo-gu, Daejeon, 35208, Republic of Korea Facsimile No. +82-42-481-8578	15 September 2017 (15.09.2017)	KIM, Seong Woo Telephone No. +82-42-481-3348

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Box No. I Basis of this opinion

1. With regard to the **language**, this opinion has been established on the basis of :

   ☒ the international application in the language in which it was filed

   ☐ a translation of the international application into _____ which is the language of a translation furnished for the purposes of international search (Rules 12.3(a) and 23.1(b))

2. ☐ This opinion has been established taking into account the **rectification of an obvious mistake** authorized by or notified to this Authority under Rule 91 (Rule 43*bis*.1(a))

3. ☐ With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, this opinion has been established on the basis of a sequence listing:

   a. ☐ forming part of the international application as filed:
      ☐ in the form of an Annex C/ST.25 text file.
      ☐ on paper or in the form of an image file.

   b. ☐ furnished together with the international application under PCT Rule 13*ter*.1(a) for the purposes of international search only in the form of an Annex C/ST.25 text file.

   c. ☐ furnished subsequent to the international filing date for the purposes of international search only:
      ☐ in the form of an Annex C/ST.25 text file (Rule 13*ter*.1(a)).
      ☐ on paper or in the form of an image file (Rule 13*ter*.1(b) and Administrative Instructions, Section 713).

4. ☐ In addition, in the case that more than one version or copy of a sequence listing has been filed or furnished, the required statements that the information in the subsequent or additional copies is identical to that forming part of the application as filed or does not go beyond the application as filed, as appropriate, were furnished.

5. Additional comments:

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Box No. V Reasoned statement under Rule 43bis.1(a)(i) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty (N)	Claims	1-35	YES
	Claims	NONE	NO
Inventive step (IS)	Claims	NONE	YES
	Claims	1-35	NO
Industrial applicability (IA)	Claims	1-35	YES
	Claims	NONE	NO

2. Citations and explanations :

Reference is made to the following documents:

D1: US 2014-0238153 A1 (ROBERT J. WOOD et al.) 28 August 2014
D2: WO 2016-205375 A1 (THE REGENTS OF THE UNIVERSITY OF MICHIGAN) 22 December 2016
D3: US 2013-0333094 A1 (THE BOARD OF TRUSTEES OF THE UNIVERSITY OF ILLINOIS) 19 December 2013

1. Novelty and Inventive Step

1.1. Claim 1

D1, which is considered to be the closest prior art to the subject matter of claim 1, discloses a method comprising:
forming an elastic strain sensor 100 from a flexible elastic substrate material 102 (see paragraph [0041] and figure 1 in D1);
curing an elastomer material (see paragraph [0066] and figure 5 in D1); and
bonding additional layers of the elastomer material using the same process (see paragraph [0066] and figure 5 in D1).

The subject matter of claim 1 differs from that of D1 in: a first elastomer layer having at least a plurality of fluid based circuits, the first elastomer layer adhering to a plurality of formation specifications; and one or more additional elastomer layers having at least a plurality of fluid based circuits, the one or more additional elastomer layers adhering to the plurality of formation specifications. However, the different features can be easily derived by a person skilled in the art from the feature of D2 in analogous art that one layer (a fluidic actuator

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Box No. VII Certain defects in the international application

The following defects in the form or contents of the international application have been noted:

Claim 21 is contrary to PCT Rule 6.1(a) because the subject matter of claims 21 and 1 is the same.

Claims 24-31 do not comply with PCT Rule 6.4(a) because multiple dependent claims should not serve as a basis for any other multiple dependent claim. (Note: The international search report and the written opinion have been established on the assumption that claims 24-31 refer to claim 21.)

Claims 24 and 25 do not comply with PCT Rule 6.4(a) because the multiple dependent claims do not refer to other claims in the alternative way.

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layer) is an array of chambers, and the other layer (a fluidic logic circuitry layer) incorporates pressure-controlled valves or fluid transistors that are configured with similar valves into fluid circuits analogous to transistor circuits in electronic devices (see paragraph [0046] and figure 1A in D2).

D1 and D2 are concerned with mutually related technical fields and there is no need for fundamental changes in the key features or for a new technical idea in combining the subject matters of D1 and D2. Accordingly, it would be obvious to a person skilled in the art to combine D1 and D2 to arrive at claim 1. Therefore, claim 1 lacks an inventive step under PCT Article 33(3).

1.2. Claims 2-15

Claims 2-15 are directly or indirectly dependent on claim 1.

The additional feature of claim 2 is merely a matter of design option in view of the feature of D2 that a fluidic NOT gate 60 (or inverter) is realized by placing a pressure-controlled flow valve 30 in series with a resistive line 62 (or fluid constriction) between a high 68 and low 69 pressure source, and a high source pressure Pdd 68 is applied at one side of the valve 30, and a low pressure Pss 69 is applied at the end of the resistive line 62 (see paragraph [0057] and figures 5A-5C in D2).

The additional feature of claim 3 is merely a matter of design option in view of the feature of D2 such as a high 68 and low 69 pressure source (see paragraph [0057] in D2).

The additional feature of claim 4 is merely a matter of design option in view of the feature of D1 that the voltage difference across each sensor can be amplified by an instrumentation amplifier, and the amplified signals can be connected to three analog-to-digital conversion ports of a microcontroller to separately measure the resistance changes (see paragraph [0072] in D1).

The additional feature of claim 5 is merely a matter of design option in view of the feature of D1 that the channel dimensions can be 200μm by 200μm for strain sensing (Layers 1 and 2) and 200μm (width) by 200μm (height) for pressure sensing (Layer 3), and the overall size of the artificial skin can be 25 mm by 25 mm, and the thickness can be approximately 3.5

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mm (see paragraph [0071] in D1).

The additional features of claims 6-8 are merely matters of design option in view of the feature of D1 that a multi-modal sensor can include three soft sensor layers made of silicone rubber that is highly stretchable and soft (modulus: 69 kPa, shore hardness: 00-30) (see paragraph [0069] in D1).

The additional feature of claim 9 is merely a matter of design option in view of the feature of D1 that the unpatterned elastomer mold can be first spin-coated with a thin, uncured layer of elastomer, which can be then partially cured at 60°C in a convection oven (see paragraph [0047] in D1).

The additional feature of claim 10 is merely a matter of design option in view of the feature of D1 that the two elastomer layers can be cured together under ambient conditions for several hours (see paragraph [0047] in D1).

The additional features of claims 11 and 12 are merely matters of design option in view of the feature of D2 that the microfluidic valve is comprised of a gain layer 50, and the time interval over which a signal propagates around a loop must be shorter than the time interval between certain features in input control signals (see paragraphs [0063], [0066] in D2).

The additional features of claims 13 and 14 are not explicitly disclosed in D1 or D2. However, they are merely matters of design option in view of the feature of D3 in analogous art that the heater can maintain a constant temperature on its support surface, useful actuating elements include electromagnetic radiation emitting elements, light emitting diodes, lasers and heating elements, and actuators also include thermal sources for heating tissue (see paragraphs [0068], [0171] in D3).

The additional feature of claim 15 is merely a matter of design option in view of the feature of D3 that the thin elastomeric substrate can be rolled over the biological surface (see paragraph [0100] in D3).

Accordingly, it would be obvious to a person skilled in the art to combine D1 and D2 to arrive at claims 2-12, and it would be obvious to a person skilled in the art to combine D1,

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D2 and D3 to arrive at claims 13-15. Therefore, claims 2-15 lack an inventive step under PCT Article 33(3).

1.3. Claim 16

D1, which is considered to be the closest prior art to the subject matter of claim 16, discloses a device comprising:
a flexible elastic substrate material 102 (see paragraph [0041] and figure 1 in D1); and
an elastic strain sensor 100 formed from the flexible elastic substrate material 102, wherein microchannels 110 and loop portions 120 can be filled with a conductive liquid 130 and strain on the sensor 120 can be determined from changes in the electrical resistance of the conductive liquid 130 as the elastic material and the conducting liquid are stretched (see paragraph [0041] and figure 1 in D1).

The subject matter of claim 16 differs from that of D1 in that a device of claim 16 comprises:
① a first via layer disposed on a surface of the sensing layer, the first via layer being an elastomer having channels for the operation of fluid-based interconnects that are fluidically coupled to one or more fluid-based circuits of the sensing layer;
② a gate layer disposed on a surface of the first via layer, the gate layer being an elastomer having channels for the operation of fluid-based gate and routing circuits that are fluidically coupled to one or more fluid-based circuits of the first via layer;
③ a second via layer disposed on a surface of the gate layer, the second via layer being an elastomer having channels for the operation of fluid-based interconnects that are fluidically coupled to one or more fluid-based circuits of the gate layer;
④ a source and drain layer disposed on a surface of the second via layer, the source and drain layer being an elastomer having channels for the operation of fluid-based source and drain circuits that are fluidically coupled to one or more fluid-based circuits of the second via layer;
⑤ a third via layer disposed on a surface of the gate layer, the third via layer being an elastomer having channels for the operation of fluid-based interconnects that are fluidically coupled to one or more fluid-based circuits of the source and drain layer; and
⑥ an actuator layer disposed on a surface of the gate layer, the actuator layer being an elastomer having channels for the operation of fluid-based actuators that are fluidically coupled

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to one or more fluid-based circuits of the third via layer.

Differences ①, ③, ⑤, however, are merely matters of design option in view of the feature of D1 that the microchannels for each layer can be aligned with a common axis and connected by holes or openings in the patterned layer(s) that provides an interconnect between layers (see paragraph [0049] in D1); difference ② can be easily derived by a person skilled in the art from the feature of D2 in analogous art that the basic building block for fluidic logic circuitry layer 18 is a pressure-controlled flow valve 30, and the pressure at the valve gate 37 controls the fluid flow between the drain 39 and source 41 (see paragraph [0060] and figure 6A in D2); difference ④ can be easily derived from the feature of D2 that a flow layer 40 is divided by a valve seat 33 that, when in contact with the control membrane 32, separates the drain 39 from the source 41 (see paragraph [0060] and figure 6A in D2); and difference ⑥ can be easily derived from the feature of D2 that one layer (a fluidic actuator layer) is an array of chambers, and the fluidic logic circuitry layer 18 and fluid actuator layer 11 are combined within a single substrate 20 (see paragraphs [0046], [0048] and figure 1A in D2).

D1 and D2 are concerned with mutually related technical fields and there is no need for fundamental changes in the key features or for a new technical idea in combining the subject matters of D1 and D2. Accordingly, it would be obvious to a person skilled in the art to combine D1 and D2 to arrive at claim 16. Therefore, claim 16 lacks an inventive step under PCT Article 33(3).

1.4. Claim 17

The additional feature of claim 17, dependent on claim 16, is merely a matter of design option in view of the features of D1 that the elastic strain sensor 100 can be sensitive to strain applied along the strain axis 104 (see paragraph [0042] in D1), and D2 that a few external fluidic control inputs 13 are able to control a plurality of fluid actuators 12 (see paragraph [0050] in D2). Accordingly, it would be obvious to a person skilled in the art to combine D1 and D2 to arrive at claim 17. Therefore, claim 17 lacks an inventive step under PCT Article 33(3).

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1.5. Claim 18

D1, which is considered to be the closest prior art to the subject matter of claim 18, discloses a device comprising:
a flexible elastic substrate material 102 (see paragraph [0041] and figure 1 in D1); and
Layer 1 bonded to Layer 0, and additional layers of an elastomer material bonded using the same process (see paragraph [0066] and figure 5 in D1).

The subject matter of claim 18 differs from that of D1 in one or more additional layers being elastomers and having channels for the operation of a fluid-based actuator, a fluid-based source, drain, and gate circuit, and a fluid-based sensing circuit. However, the different features can be easily derived from the features of D1 that an elastic strain sensor 100 can be formed from a flexible elastic substrate material 102, and microchannels 110 and loop portions 120 can be filled with a conductive liquid 130 and the strain on the sensor 120 can be determined from changes in the electrical resistance of the conductive liquid 130 as the elastic material and the conducting liquid are stretched (see paragraph [0041] and figure 1 in D1), and D2 in analogous art that: one layer (a fluidic actuator layer) is an array of chambers, and the fluidic logic circuitry layer 18 and fluid actuator layer 11 are combined within a single substrate 20 (see paragraphs [0046], [0048] and figure 1A in D2); and the basic building block for fluidic logic circuitry layer 18 is a pressure-controlled flow valve 30, and the pressure at the valve gate 37 controls the fluid flow between the drain 39 and source 41 (see paragraph [0060] and figure 6A in D2).

D1 and D2 are concerned with mutually related technical fields and there is no need for fundamental changes in the key features or for a new technical idea in combining the subject matters of D1 and D2. Accordingly, it would be obvious to a person skilled in the art to combine D1 and D2 to arrive at claim 18. Therefore, claim 18 lacks an inventive step under PCT Article 33(3).

1.6. Claims 19 and 20

Claims 19 and 20 are dependent on claim 18.

The additional feature of claim 19 is merely a matter of design option in view of the

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feature of D1 that the strain sensor 100 can be formed from a flexible elastic substrate material 102 (see paragraph [0041] in D1).

The additional feature of claim 20 is merely a matter of design option in view of the feature of D2 that the fluidic logic circuitry layer 18 and fluid actuator layer 11 are combined within a single substrate 20 (see paragraph [0048] in D2).

Accordingly, it would be obvious to a person skilled in the art to combine D1 and D2 to arrive at claims 19 and 20. Therefore, claims 19 and 20 lack an inventive step under PCT Article 33(3).

1.7. Claim 21

The features of claim 21 are substantially the same as those of claim 1. Accordingly, it would be obvious to a person skilled in the art to combine D1 and D2 to arrive at claim 21. Therefore, claim 21 lacks an inventive step under PCT Article 33(3).

1.8. Claims 22-31

Claims 22-31 are directly or indirectly dependent on claim 21.

The additional features of claim 22 are merely matters of design option in view of the feature of D2 that a fluidic NOT gate 60 (or inverter) is realized by placing a pressure-controlled flow valve 30 in series with a resistive line 62 (or fluid constriction) between a high 68 and low 69 pressure source, and a high source pressure Pdd 68 is applied at one side of the valve 30, and a low pressure Pss 69 is applied at the end of the resistive line 62 (see paragraph [0057] and figures 5A-5C in D2).

The additional feature of claim 23 is merely a matter of design option in view of the feature of D1 that the voltage difference across each sensor can be amplified by an instrumentation amplifier, and the amplified signals can be connected to three analog-to-digital conversion ports of a microcontroller to separately measure the resistance changes (see paragraph [0072] in D1).

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The additional feature of claim 24 is merely a matter of design option in view of the feature of D1 that the channel dimensions can be 200μm by 200μm for strain sensing (Layers 1 and 2) and 200μm (width) by 200μm (height) for pressure sensing (Layer 3), and the overall size of the artificial skin can be 25 mm by 25 mm, and the thickness can be approximately 3.5 mm (see paragraph [0071] in D1).

The additional features of claims 25 and 26 are merely matters of design option in view of the feature of D1 that a multi-modal sensor can include three soft sensor layers made of silicone rubber that is highly stretchable and soft (modulus: 69 kPa, shore hardness: 00-30) (see paragraph [0069] in D1).

The additional feature of claim 27 is merely a matter of design option in view of the feature of D1 that the unpatterned elastomer mold can be first spin-coated with a thin, uncured layer of elastomer, which can be then partially cured at 60°C in a convection oven (see paragraph [0047] in D1).

The additional feature of claim 28 is merely a matter of design option in view of the feature of D1 that the two elastomer layers can be cured together under ambient conditions for several hours (see paragraph [0047] in D1).

The additional features of claim 29 are merely matters of design option in view of the feature of D2 that the microfluidic valve is comprised of a gain layer 50, and the time interval over which a signal propagates around a loop must be shorter than the time interval between certain features in input control signals (see paragraphs [0063], [0066] in D2).

The additional features of claim 30 are not explicitly disclosed in D1 or D2. However, they are merely matters of design option in view of the feature of D3 in analogous art that the heater can maintain a constant temperature on its support surface, useful actuating elements include electromagnetic radiation emitting elements, light emitting diodes, lasers and heating elements, and actuators also include thermal sources for heating tissue (see paragraphs [0068], [0171] in D3).

The additional feature of claim 31 is merely a matter of design option in view of the feature of D3 that the thin elastomeric substrate can be rolled over the biological surface (see

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paragraph [0100] in D3).

Accordingly, it would be obvious to a person skilled in the art to combine D1 and D2 to arrive at claims 22-29, and it would be obvious to a person skilled in the art to combine D1, D2 and D3 to arrive at claims 30 and 31. Therefore, claims 22-31 lack an inventive step under PCT Article 33(3).

1.9. Claim 32

D1, which is considered to be the closest prior art to the subject matter of claim 32, discloses a device comprising:
a flexible elastic substrate material 102 (see paragraph [0041] and figure 1 in D1); and
Layer 1 bonded to Layer 0, and additional layers of an elastomer material bonded using the same process (see paragraph [0066] and figure 5 in D1).

The subject matter of claim 32 differs from that of D1 in ① one or more additional layers being elastomers and having channels for the operation of a fluid-based actuator, a fluid-based source, drain, and gate circuit, and a fluid-based sensing circuit, ② wherein at least two of the one or more of the additional layers are optionally formed on a same physical layer. However, difference ① can be easily derived from the features of D1 that an elastic strain sensor 100 can be formed from a flexible elastic substrate material 102, and microchannels 110 and loop portions 120 can be filled with a conductive liquid 130 and the strain on the sensor 120 can be determined from changes in the electrical resistance of the conductive liquid 130 as the elastic material and the conducting liquid are stretched (see paragraph [0041] and figure 1 in D1), and D2 in analogous art that: one layer (a fluidic actuator layer) is an array of chambers, and the fluidic logic circuitry layer 18 and fluid actuator layer 11 are combined within a single substrate 20 (see paragraphs [0046], [0048] and figure 1A in D2); and the basic building block for fluidic logic circuitry layer 18 is a pressure-controlled flow valve 30, and the pressure at the valve gate 37 controls the fluid flow between the drain 39 and source 41 (see paragraph [0060] and figure 6A in D2). And difference ② is merely a matter of design option in view of the feature of D2 that the fluidic logic circuitry layer 18 and fluid actuator layer 11 are combined within a single substrate 20 (see paragraph [0048] in D2).

D1 and D2 are concerned with mutually related technical fields and there is no need for

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fundamental changes in the key features or for a new technical idea in combining the subject matters of D1 and D2. Accordingly, it would be obvious to a person skilled in the art to combine D1 and D2 to arrive at claim 32. Therefore, claim 32 lacks an inventive step under PCT Article 33(3).

1.10. Claims 33-35

Claims 33-35 are directly or indirectly dependent on claim 32.

The additional features of claim 33 are merely matters of design option in view of the features of D1 and D2 that: the strain sensor 100 can be formed from a flexible elastic substrate material 102, wherein microchannels 110 and loop portions 120 can be filled with a conductive liquid 130 and the strain on the sensor 120 can be determined from changes in the electrical resistance of the conductive liquid 130 as the elastic material and the conducting liquid are stretched (see paragraph [0041] and figure 1 in D1); the microchannels for each layer can be aligned with a common axis and connected by holes or openings in the patterned layer(s) that provides an interconnect between layers (see paragraph [0049] in D1); the basic building block for fluidic logic circuitry layer 18 is a pressure-controlled flow valve 30, and the pressure at the valve gate 37 controls the fluid flow between the drain 39 and source 41 (see paragraph [0060] and figure 6A in D2); a flow layer 40 is divided by a valve seat 33 that, when in contact with the control membrane 32, separates the drain 39 from the source 41 (see paragraph [0060] and figure 6A in D2); and one layer (a fluidic actuator layer) is an array of chambers, and the fluidic logic circuitry layer 18 and fluid actuator layer 11 are combined within a single substrate 20 (see paragraphs [0046], [0048] and figure 1A in D2).

The additional feature of claim 34 is merely a matter of design option in view of the features of D1 that the elastic strain sensor 100 can be sensitive to strain applied along the strain axis 104 (see paragraph [0042] in D1), and D2 that a few external fluidic control inputs 13 are able to control a plurality of fluid actuators 12 (see paragraph [0050] in D2).

The additional feature of claim 35 is merely a matter of design option in view of the feature of D1 that the strain sensor 100 can be formed from a flexible elastic substrate material 102 (see paragraph [0041] in D1).

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Accordingly, it would be obvious to a person skilled in the art to combine D1 and D2 to arrive at claims 33-35. Therefore, claims 33-35 lack an inventive step under PCT Article 33(3).

2. Industrial Applicability

Claims 1-35 are industrially applicable under PCT Article 33(4).